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Review

Green Concrete mix using solid waste and nanoparticles as alternatives – A review

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HIGHLIGHTS

- Green concrete mix to minimize CO_2 emission and environmental pollution.
- Substitution of cement and aggregates with various waste materials.
- Green house gases effects resolution by implementation of nanotechnology.
- Study on use of industrial waste in cement concrete – pathway to advance studies.

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ABSTRACT

The process of manufacturing of ordinary Portland cement (OPC) is energy intensive and creates various environmental problems such as pollution and emission of CO_2. There is a need for the an alternative eco-friendly Green Concrete. The waste materials from agriculture, industries, bio-waste, marine waste and e-waste can be recycled and used as a supplementary Green Concrete materials. This will reduce environmental impact of the production of OPC and reduces energy consumption. The application of nanotechnology for a Green building in the current and future is very much significant. The production and implementation of Green Concrete is still in its infancy stage. Academicians and R & D need to step in by promoting application at the industry level. The focus of this review paper is to create awareness to utilize the discarded materials as well as to highlight the new technology to manufacture Green Concrete.

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1. Introduction

The economy of any country grows based on the infrastructure available. Infrastructure covers roads, bridges, buildings, warehouses, airports, harbors, container terminals etc. As the demand for infrastructure grows, so does the need for concrete, which leads to the demand of more cement. Cement concrete is in great demand in the construction industry and at the same time it is an environmental concern, as it produces hazardous gases in various stages of production. We generally know that any concrete mix has cement, aggregates, sand, water and additives as per design need. With growing demand to control pollution and use waste materials from different industries, this is an attempt to replace standard materials with alternative substitutes. It covers the effects on compressive strength, setting time, cost effectiveness and reduction of pollution levels. Natural resources are not perennial, so we need to find alternatives to replace them without compromising on the quality and effective parameters of the ultimate product. The cement kilns produce hazardous gases and contribute to global warming. Animals are also adversely affected by the pollution caused by cement plants. During transport of cement bags from manufacturing site to end user, it undergoes wear and tear and cement dust flies into the environment. It causes breathing diseases and effects the labor who used to transfer, dump and redistribute the stored cement bags. Solid waste management is a major concern due to increase of quantity of waste materials and industrial by-products. This is increasing the land filling problems and recycling cost of waste materials. Utilization of these materials as Green Concrete is the only option to reduce the disposal concern. The Green Concrete is made from the eco-friendly waste materials and ushers in a revolution in the concrete industries by its technology. The waste products can be reused directly as a partial substitute of cement and save the energy consumption during the production of cement. Some waste materials are having pozzolans properties. Pozzolans is a material rich in silica and alumina which itself possess little or no cementing property, but in the presence of water, it chemically reacts with calcium hydroxide at ordinary temperature to form the cementitious properties [1].

The complete process of cement manufacturing, right from crushing and transport of lime stone, heating of kilns and crushing is all polluting. The river sand is used as fine aggregate for the concrete mixes which is obtained from the river beds and erodes the valuable top soil. Since sand mining is a lucrative business does not benefit the government economically and disturbs the ecology of the rivers. Water flow is uneven and the river bed is degraded. Coarse aggregate is gravel powdered and pounded to sizes from granite and blue stones. This also makes mining and blue metal companies to chip and blast mountains. Most of the mountains are completely chipped off which influences the rainfall pattern. Pollution and ash dust flying in the air is a major disadvantage of blue metal quarrying. It is also powdered to manufacture M-sand, a cheaper alternative to river sand. Volcanic materials and thermally processed materials can be also used as lightweight aggregates as natural resources. Water is a major commodity and usually potable grade water is best suited for cement concrete mix manufacturing. Water is depleting and recycled water must be replaced in the system to have a sustainable supply of water. Concrete mix causes release of green house gases (CO_2) and pollutes the atmosphere. Concrete is the most used material in construction industry and it undergoes various types of deterioration due to environmental effects.

An enormous amount of waste materials from different surroundings, environments and industries are produced every day. The waste materials such as rice husk ash (RHA), saw dust ash (SDA), rubber crump, plastic waste, coconut husk and shell, textile waste (sludge and fiber) etc lead to waste disposal crisis. Recycle of such types of wastes can be used as an admixture to make the Green Concrete structures. This will reduce the quantity of cement used and CO_2 emission and reduce the global warming. In this paper, the explanation is about the waste materials as an admixture which provides better strength and durability of concrete than the existing one which not only solves the environmental and ecological problems but also significantly improves the microstructures and durability properties of concrete. The demolished building waste is mixed in concrete which saves the space required to dispose them and at the same time they get recycled and fresh material is not needed.

This paper explains the three different types of resources such as resources of agriculture, industries and bio-waste. By implementing nanotechnology, the properties of concrete structures can be improved.

2. Material resources

2.1. Resources of agriculture

Plant-based agricultural wastes such as rice husk, timber waste as saw dust, palm oil fuel ash and coconut shell are the sustainable resources to produce concrete.

2.1.1. Rice husk ash (RHA)

Rice husk is an agricultural waste obtained from milling of rice which is one of the largest available un-utilized biomass resources. The disposal of this natural waste is a great problem because of pollution. RHA is highly pozzolanic (siliceous materials) due to its extremely high surface area. It contains 90–95% SiO_2 which is an essential ingredient in concrete whereas OPC contains only 21% of SiO_2. The waste generated from the rice field, as RHA can be incorporated in the concrete mix (Green Concrete) to improve workability, strength, durability and decrease the cement quantity. RHA forms a calcium silicate hydrate gel (C-S-H) which can stop the cracking of the concrete and save it from any corrosion and leaching. The use of RHA in concrete showed the development of strength [2,3]. In self-compacting concrete, RHA solves the disposal problem, thus keeping the environment free from pollution [4]. Silica present in the RHA combines with the calcium hydroxide and forms a resistive on the material, under acidic conditions. Ramezanianpour et al. (2009) showed that concrete incorporating RHA modified concrete is having superior compressive, splitting tensile strength and modulus of elasticity is different compared with that of the controlled concrete [5]. Alireza et al. (2010) used RHA as pozzolanic material in mortar and concrete [6]. It improve the improve the mechanical and durability properties. Ramasamy (2012) found that addition of 20% RHA showed higher resistance against sulphate attack [7]. Krishna (2012) discussed about the effectiveness of RHA as a versatile concrete admixture and application of RHA concrete [8]. Godwin (2013) proved that by using RHA, concrete can be modified which is the proper replacement percentages and used in the form of